Multimedia Systems
Lecture – 18

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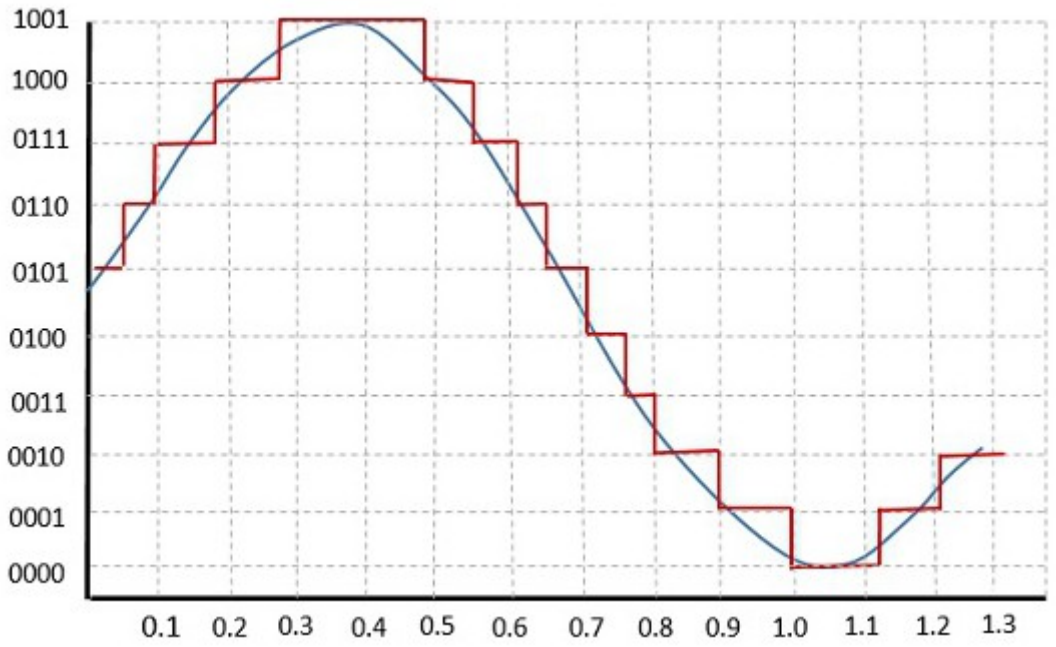
Linear and Nonlinear/ Uniform and Non-uniform Quantization

- Samples are typically stored as uniformly quantized values. This is called *linear or uniform quantization.*



- There are two types of uniform quantization. They are *Mid-Rise* type and *Mid-Tread* type.
- The **Mid-Rise** type is so called because the origin lies in the middle of a raising part of the stair-case like graph. The quantization levels in this type are even in number.
- The **Mid-tread** type is so called because the origin lies in the middle of a tread of the stair-case like graph. The quantization levels in this type are odd in number.
- The difference between an input value and its quantized value is called a **Quantization Error**.

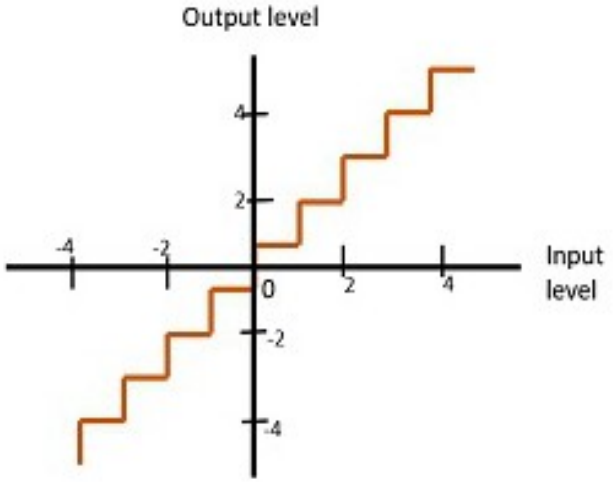


Fig 1 : Mid-Rise type Uniform Quantization

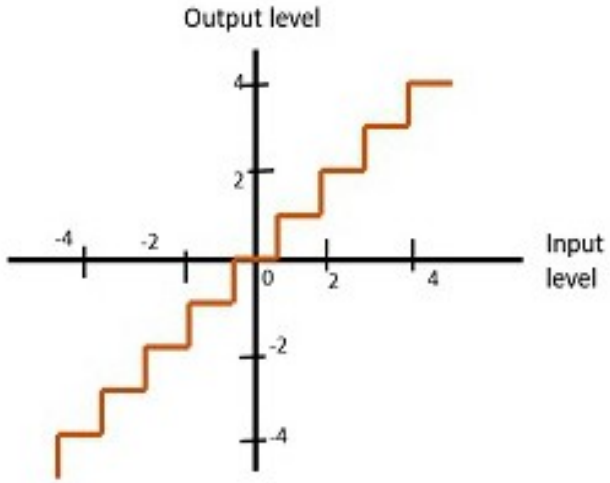


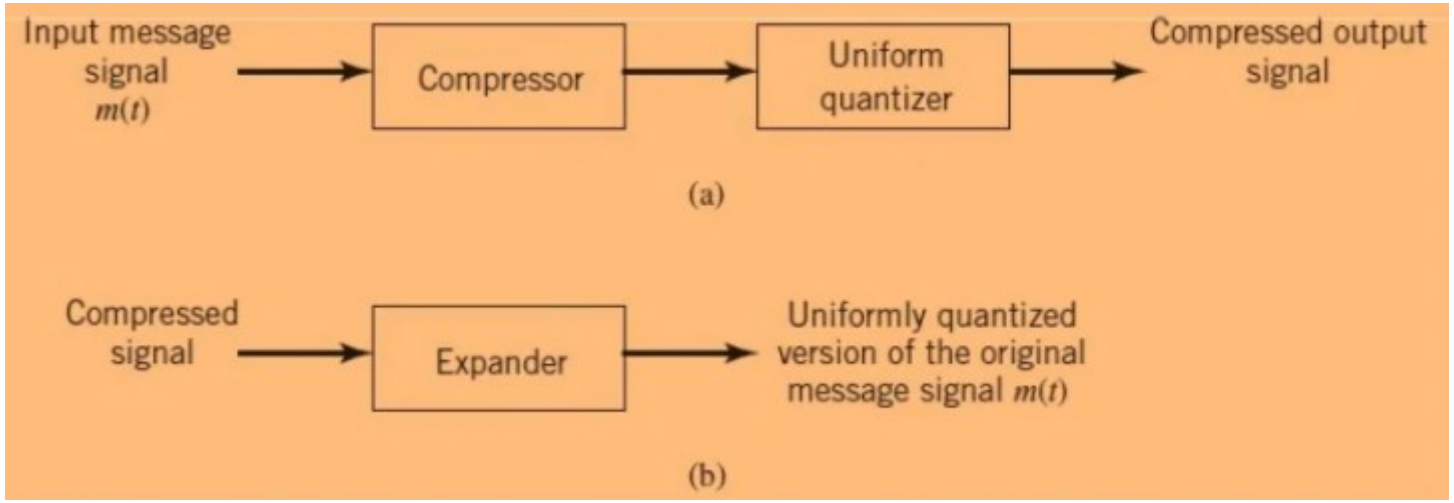
Fig 2 : Mid-Tread type Uniform Quantization

Non-uniform Quantization

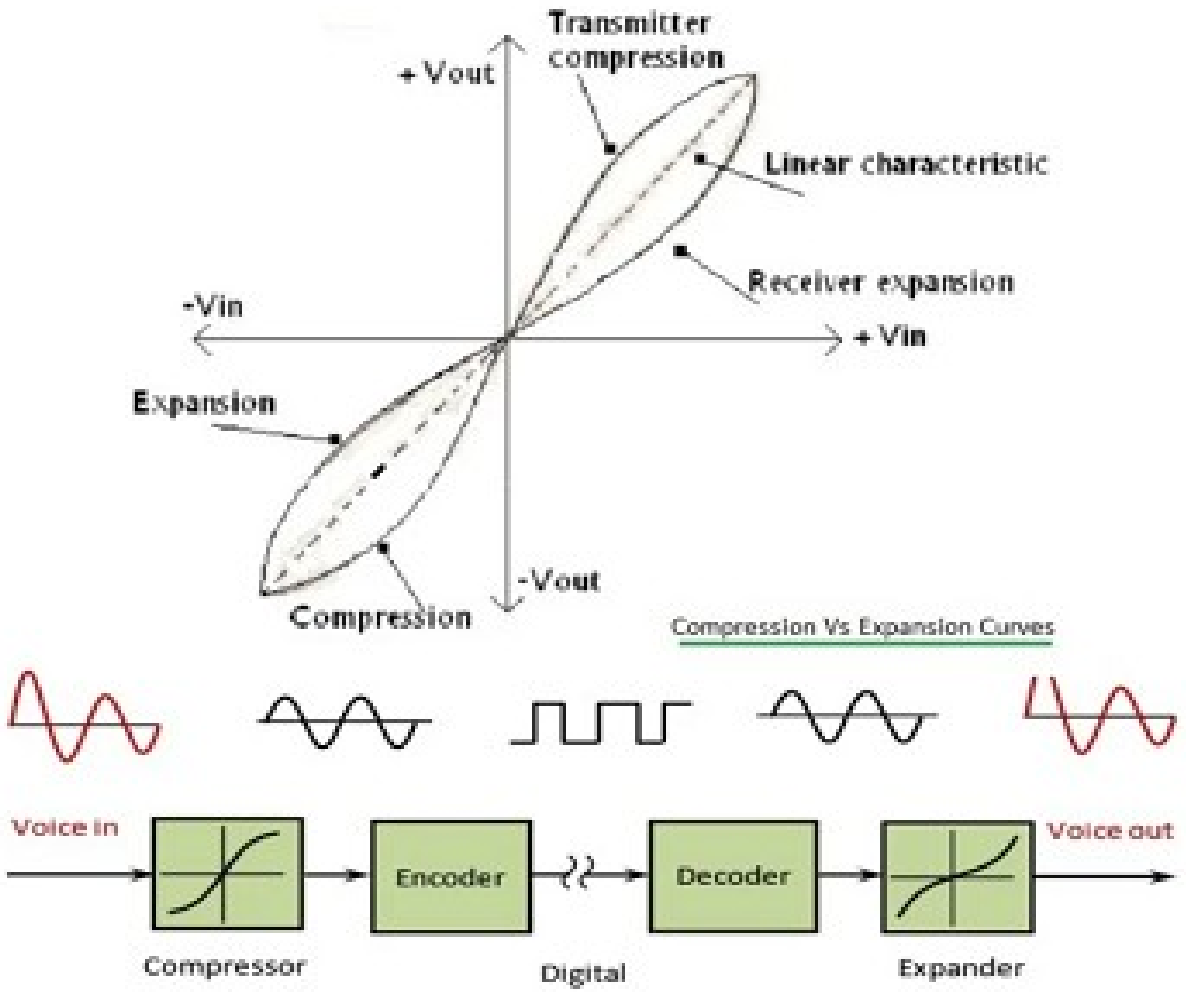
- If the quantization characteristic is nonlinear then the step size is not constant and quantization is known as non-uniform quantization.
- It is mostly used in case of speech or music as here the variation in amplitude is high which is expressed as crest factor and is given by

  crest factor = peak value of signal/rms value of signal
- Non-uniform quantization is achieved using companding.

- Companding:
- It is derived from two words, ***Compressing*** and ***Expanding***.
- The desired form of non-uniform quantization can be achieved by using compressor followed by a uniform quantizer.



Companding Process



μ-law and A-law companding

- μ-law is popular technique used in USA and Japan.
- Here the input and output relationship is given by

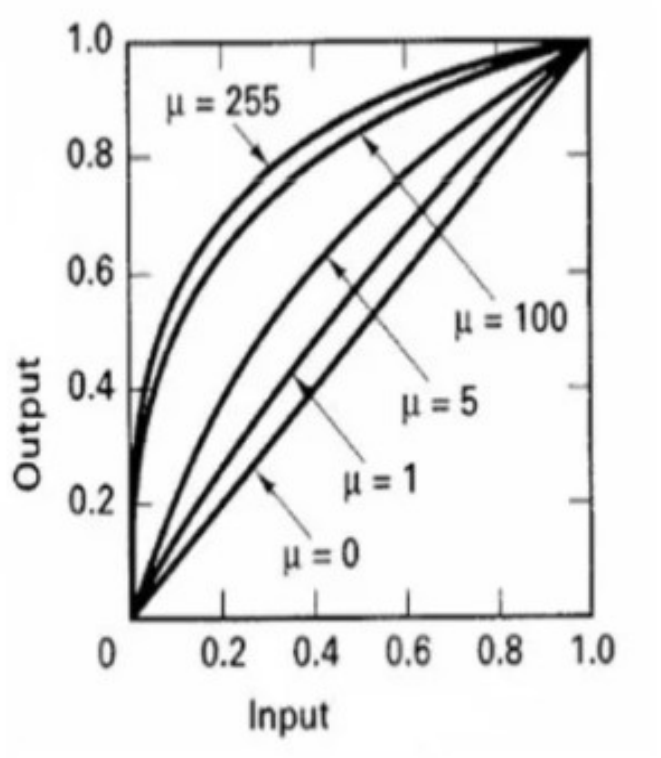
$$r = \frac{\text{sign}(s)}{\ln(1+\mu)} \ln\left\{1 + \mu\left|\frac{s}{s_p}\right|\right\}, \qquad \left|\frac{s}{s_p}\right| \le 1$$

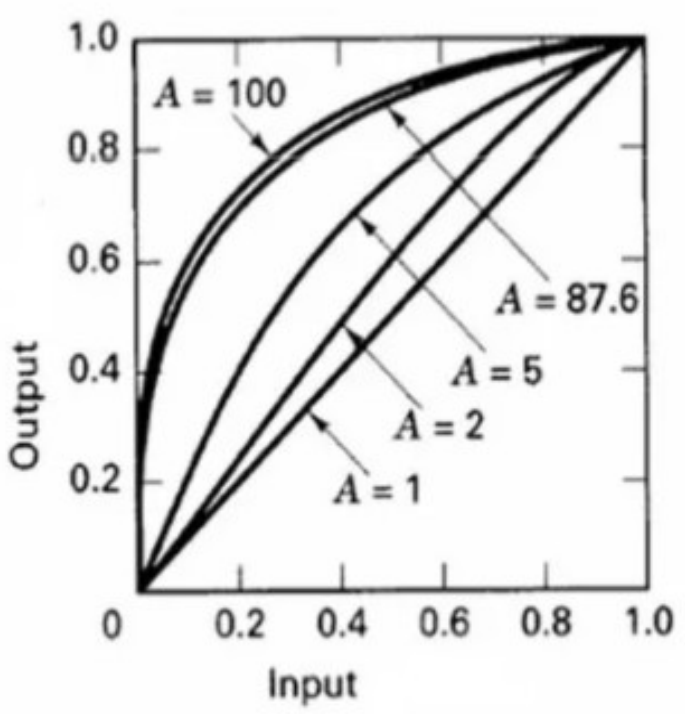
- A very similar rule, called *A-law*, is used in telephony in Europe.

$$r = \begin{cases} \frac{A}{1+\ln A}\left(\frac{s}{s_p}\right), & \left|\frac{s}{s_p}\right| \le \frac{1}{A} \\ \frac{\text{sign}(s)}{1+\ln A}\left[1 + \ln A\left|\frac{s}{s_p}\right|\right], & \frac{1}{A} \le \left|\frac{s}{s_p}\right| \le 1 \end{cases}$$

$$\text{where } \text{sign}(s) = \begin{cases} 1 & \text{if } s > 0, \\ -1 & \text{otherwise} \end{cases}$$

μ-law and A-law Compression Characteristics





Pulse Code Modulation (PCM)

- **Modulation** is the process of varying one or more parameters of a carrier signal in accordance with the instantaneous values of the message signal.
- There are many modulation techniques, which are classified according to the type of modulation employed. Of them all, the digital modulation technique used is **Pulse Code Modulation.**
- We know that the basic techniques for creating digital signals from analog ones consist of *sampling* and *quantization*.
- Pulse Code Modulation, is a formal term for the sampling and quantization we have already been using.
- *Pulse* comes from an engineer's point of view that the resulting digital signals can be thought of as infinitely narrow vertical "pulses."

Basic Elements of PCM